Study on the Community Characteristics of *Bauhinia bohniana*, an Endemic Vegetation of the Jinsha River Valley

2026-06-26

ChinaRxiv

Abstract

Dry-warm valley shrublands are an important vegetation type in the middle Jinsha River valley, and the Bauhinia bohniana community is a relict endemic shrubland discovered in recent years. At present, studies of valley shrublands have mostly focused on vegetation in dry-hot valleys, while research on the community characteristics and ecological traits of dry-warm valley vegetation remains limited. This study investigated the characteristics and current distribution of the Bauhinia bohniana community using UAV imagery and quadrat surveys. The results showed that: (1) A total of 194 vascular plant species were recorded in 22 quadrats, belonging to 120 genera and 57 families. The dominant families were Fabaceae and Poaceae, and the dominant genera were Carex and Selaginella. The flora exhibited a tropical–temperate transitional character, with tropical elements accounting for 56.5% and temperate elements for 43.5% at the genus level. At the species level, Chinese endemic species predominated, including 51 indicator species of the dry-warm Jinsha River valley, reflecting relict evolution and specialization under the combined effects of the retreat of the ancient Mediterranean and the uplift of the Qinghai-Tibet Plateau. (2) The community had a distinct vertical structure, with shrub-layer coverage of 30%–70%, herb-layer coverage of 10%–50%, and interlayer coverage of 1%–3%. Its physiognomy showed typical xerophytic deciduous characteristics: yellowing and sparse in the dry season, regreening in the rainy season, and markedly delayed phenology. The species diversity index of the shrub layer was higher than that of the herb layer. (3) The community life-form spectrum was dominated by hemicryptophytes (41.2%) and phanerophytes (34.5%). Leaf miniaturization (50.5%), chartaceous texture (64.1%), and deciduousness were prominent, reflecting convergent adaptive strategies to drought stress. In adaptive strategies, the community resembles African savanna communities and Mediterranean shrublands, while the relatively high proportion of temperate genera (43.5%) indicates its geographical transitionality. This study is of great significance for revealing the historical evolution of the Jinsha River valley and for ecological conservation in the middle Jinsha River.

Full Text

DOI:10.11931/guihaia.gxzw202412020

Study on the Community Characteristics of *Bauhinia bohniana*, an Endemic Vegetation of the Jinsha River Valley

XU Mengwei1, DU Fan1, WEI Jiansheng2, WANG Jingxian3, SHI Ming1*, HE Chengcheng1, ZHOU Xunkang1

(1. College of Forestry, Southwest Forestry University, Kunming 650224, China;

2. Haba Snow Mountain Provincial Nature Reserve of Yunnan Province, Diqing 674400, Yunnan, China; 3. Yunnan Jinfan Forestry Co., Ltd., Kunming 650224, China)

Abstract: Dry-warm valley shrubland is an important vegetation type in the middle reaches of the Jinsha River valley, and the *Bauhinia bohniana* community is a relict endemic shrubland discovered in recent years. At present, studies of valley shrublands have mostly focused on dry-hot valley vegetation, while research on the community characteristics and ecological features of dry-warm valley vegetation remains insufficient. In this study, drone photography and quadrat surveys were used to investigate the community characteristics and current distribution of the *Bauhinia bohniana* community. The results showed that: (1) A total of 194 vascular plant species belonging to 120 genera and 57 families were recorded in 22 quadrats. The dominant families were Fabaceae and Poaceae, and the dominant genera were *Carex* and *Selaginella*. The floristic composition showed a tropical–temperate transitional pattern: tropical elements accounted for 56.5% and temperate elements for 43.5% at the genus level. At the species level, Chinese endemic species predominated, including 51 indicator species of the dry-warm valleys of the Jinsha River, reflecting relict evolution and specialization under the combined effects of the retreat of the ancient Mediterranean Sea and the uplift of the Qinghai–Tibet Plateau. (2) The community had a distinct vertical structure: shrub-layer cover was 30%–70%, herb-layer cover was 10%–50%, and interlayer cover was 1%–3%. Its physiognomy exhibited typical drought-deciduous characteristics, with yellowing and sparse cover in the dry season, re-greening in the rainy season, and markedly delayed phenology. The species diversity index of the shrub layer was higher than that of the herb layer. (3) The life-form spectrum of the community was dominated by hemicryptophytes (41.2%) and phanerophytes (34.5%); leaves were predominantly small (50.5%) and papery (64.1%), and deciduousness was pronounced, reflecting the community' s adaptive strategy under drought stress. In adaptive strategy, the community resembled African savanna communities and Mediterranean shrublands, but its relatively high proportion of temperate elements (43.5%) reflected geographical transitionality. This study is of great significance for revealing the historical evolution of the Jinsha River valley and for ecological conservation in the middle reaches of the Jinsha River.

Keywords: *Bauhinia bohniana*; dry-warm valley shrubland; community characteristics; species composition; Jinsha River

Chinese Library Classification No.: Q948
Document Identification Code: A
Article No.:

Characteristics of the *Bauhinia bohniana* community, a unique vegetation in the Jinsha River Valley

XU Mengwei1, DU Fan1, WEI Jiansheng2, WANG Jingxian3, SHI Ming1*, HE Chengcheng1, ZHOU Xunkang1

(1. *College of Forestry, Southwest Forestry University*, Kunming 650224, China; 2. *Haba Snow Mountain Nature Reserve of Yunnan Province*, Diqing 674400, Yunnan, China; 3. *Yunnan Jinfan Forestry Co., Ltd.* Kunming 650200, China)

Abstract: The dry-warm valley shrubland is a significant vegetation type in the middle Jinsha River valley. The *Bauhinia bohniana* scrub is a recently discovered endemic community of this type. Current research on valley shrublands has largely focused on dry-hot valley vegetation, and there is a lack of research on the community and ecological characteristics of dry-warm valley vegetation. This study uses drone photography and the quadrat method to investigate the characteristics and current distribution of the *Bauhinia bohniana* community. The results were as follows: (1) In 22 surveyed *Bauhinia bohniana* community quadrats, 194 vascular plant species were recorded, belonging to 57 families and 120 genera. Fabaceae and Poaceae were the dominant families, while *Carex* and *Selaginella* were the dominant genera. The flora showed a tropical–temperate transitional pattern, with 56.5% tropical and 43.5% temperate genera. At the species level, Chinese endemics dominated, including 51 indicator species of the Jinsha dry-warm valleys, reflecting relict evolution and specialization driven by the retreat of the Tethys and the uplift of the Qinghai–Tibet Plateau. (2) The community exhibited a distinct vertical structure: shrub-layer cover ranged from 30% to 70%, herb-layer cover from 10% to 50%, and interlayer cover from 1% to 3%. It had a typical drought-deciduous

---

Funding project: Major Project of the Yunnan Provincial Basic Research Special Program, compilation of *Vegetation of Yunnan* (202101BC070002).
First author: XU Mengwei (1998-), master' s student; research mainly focused on plant taxonomy and diversity. (Email) Mengweixo0@163.com.
Corresponding author: SHI Ming, master, lecturer; research mainly focused on bamboo taxonomy and biodiversity. (Email) 497445471@qq.com.

This version posted 2026-06-26.

appearance, turning sparse and yellow in the dry season and regreening in the rainy season, with a delayed phenology compared to surrounding areas. The species diversity index of the shrub layer is higher than that of the herb layer. (3) The life-form spectrum was dominated by hemicryptophytes (41.2%) and phanerophytes (34.5%). Prominent adaptive traits included a predominance of small leaves (microphylls, 50.5%), papery leaf textures (64.1%), and a deciduous habit, which indicated convergent adaptation to drought stress. The community shared adaptive strategies with African savannas and Mediterranean shrublands but had a higher proportion of temperate genera (43.5%), highlighting its transitional nature. This study is of great significance for revealing the historical evolution of the Jinsha River valley and provides a scientific basis for the ecological conservation of its middle reaches.

Key words: *Bauhinia bohniana*, dry warm valley shrubland, community characteristics, species composition, Jinsha River

The Jinsha River is located in Southwest China, spanning the Qinghai–Tibet Plateau, the Hengduan Mountains, and the Yunnan–Guizhou Plateau. As the upper reach of the Yangtze River (Li et al., 2020), it is of great significance for maintaining the ecological balance and biological security of the Yangtze River Basin and has long been a region of intense concern in both academic and applied fields. However, with the intensification of climate change and human activities, ecosystem degradation in the Jinsha River Basin has become severe (Zhao Donglin and Zhu Shirong, 2023; Ruan Changming et al., 2024). Dry warm valley shrubland is the main vegetation type in the middle reaches of the Jinsha River valley. Over the long term, shaped by valley landforms, climate, and other topographic factors, as well as by human disturbance, these communities have become fragmented in distribution (Shen Zehao et al., 2016). Studies of vegetation in the dry valleys of the Jinsha River can be traced back to 1986, when Wu Sugong et al. (1986) first recorded the vegetation of this region during scientific investigations of the Hengduan Mountains. Since 1991, Professor Jin Zhenzhou' s team at Yunnan University has systematically studied the flora of the dry-hot and dry-warm valleys of the Yuanjiang, Nujiang, and Jinsha rivers (Jin Zhenzhou, 2002). These studies laid the foundation for understanding the phytogeography of the Jinsha River Basin and the laws governing vegetation succession in its ecological environments.

Lijiang bauhinia (*Bauhinia bohniana*) is a deciduous shrub of the family Fabaceae and the genus *Bauhinia*, established by Chen (1938) based on the specimen Forrest 15419. To date, Lijiang bauhinia is known to occur only in the dry warm valley area within an approximately 100 km stretch of the middle Jinsha River at the junction of Lijiang, Ninglang, and Shangri-La in northwestern Yunnan, and it is an endemic species of the Jinsha River Basin. Because it has few distribution sites, no research reports on Lijiang bauhinia have appeared for more than 80 years. In 2023, during a scientific expedition in the Yunnan Haba Snow Mountain Provincial Nature Reserve, our project team discovered a shrub community dominated by Lijiang bauhinia along the Jinsha River, forming a contiguous area of approximately 300 hm^2. Although small in area, it represents a vegetation type unique to the dry warm valleys of the Jinsha River, formed within the enclosed environment of the deeply incised V-shaped Jinsha River canyon, and its resources are therefore extremely precious. In view of the uniqueness of Lijiang bauhinia shrubland, this study takes the Lijiang bauhinia shrubland of the dry warm valley of the Jinsha River as its research object. Based on continuous field survey data from 2022 to 2024, and using community ecology and GIS spatial analysis methods, it aims to explore the following scientific questions: (1) how the species diversity, floristic composition, and life-form spectrum of the Lijiang bauhinia community reflect the filtering effects of dry warm valley habitats; (2) the structural characteristics of the Lijiang bauhinia community; and (3) the current status and ecological significance of indicator species of the dry warm valleys of the Jinsha River within the community.

1 Overview of the Study Area and Methods

1.1 Overview of the Study Area

The study area is located on the left bank at the bottom of the V-shaped Jinsha River valley between Haba Snow Mountain and Yulong Snow Mountain in northwestern Yunnan. The valley is deeply incised and narrow (Fig. 1), and belongs to the experimental zone of the Yunnan Haba Snow Mountain Provincial Nature Reserve. The lowest elevation along the river is 1,550 m, and nearby settlements include Jiangbian Village, Baimachang Village, and Zanba Village. The study area is a limestone region. Areas with relatively low rock exposure and gentle terrain have been reclaimed as cultivated land, while Lijiang bauhinia communities persist in valley areas with relatively high rock exposure. According to data for this valley area from 2013 to 2022 provided by the automatic meteorological station at Daju Township, Lijiang City, on the opposite bank of the Jinsha River near the study area (elevation 1,758 m), the mean annual temperature of the region is 15-22 °C; temperatures above 10 °C occur for 208-320 d throughout the year; the mean temperature of the hottest month (July) is 22-24 °C; the mean temperature of the coldest month (January) is 10-13 °C; and the frost-free period is about 200 d per year. Annual precipitation is 301.8-631.6 mm, of which approximately 70% is concentrated in July-August. August is the peak rainfall period (139.38 mm), while January has the least rainfall (1.51 mm).

Fig. 1 Geographic location of the study area

1.2 Research Methods

1.2.1 Quadrat Survey

At the end of October 2022, from April to June 2023, and in July 2024, UAV image acquisition and the typical quadrat method were used. In areas where the species occurred in contiguous patches and human disturbance was slight, 22 quadrats of 20 m × 20 m were established (Table 1). For each quadrat, habitat factors—including altitude, aspect, slope, slope position, and geographic coordinates—as well as species, traits, coverage, height, phenology, and vitality were recorded, and specimens were collected for species identification. The areas surveyed in the three investigations were consistent. During the first survey, the quadrats were established and positioned using GPS, and the four corners of each quadrat were marked to facilitate the second and third surveys.

Table 1 Basic information on quadrats for the investigation of the *Bauhinia bohniana* community

Plot	Altitude (m)	Slope (°)	Aspect	Number of species
1	1 650	30	East (E)	24
2	1 660	20	E 15 N (E15N)	35
3	1 666	25–40	E 30 S (E30S)	24
4	1 670	25	E 30 S (E30S)	16
5	1 680	25	E 30 S (E30S)	19
6	1 688	25	E 30 S (E30S)	17
7	1 830	25	E 20 S (E20S)	18
8	1 920	25	E 20 S (E20S)	24
9	1 920	32	E 45 S (E45S)	14
10	1 920	30	E 45 N (E45N)	21
11	1 920	13	East (E)	17
12	1 940	30	E 45 N (E45N)	24
13	2 000	12	East (E)	31
14	2 000	10	E 30 S (E30S)	30
15	2 000	15	E 30 N (E30N)	37
16	2 000	21	E 40 N (E40N)	26
17	2 000	27	E 40 N (E40N)	30
18	2 137	25	Southeast (SE)	37
[[header not visible]]	[[header not visible]]	[[header not visible]]	[[header not visible]]	[[header not visible]]
19	2 138	26	East E	35
20	2 154	28	Southeast SE	29
21	2 190	35	East E	34
22	2 250	25	East E	24

1.2.2 Data analysis

The distribution-area types of genera and species of seed plants were classified with reference to *Areal-types of Chinese Seed Plant Genera* by Academician Wu Zhengyi (1991); the distribution-area types of pteridophytes were classified with reference to *Pteridophyte Flora* by Professor Lu Shugang (2004); life forms were classified according to Raunkiaer’ s life-form classification system (Song Yongchang, 2001). Leaf physiognomic characteristics were determined on the basis of the field survey, including leaf texture, leaf type, and leaf-margin type.

Leaf-size classes were classified according to the criteria in *Vegetation Ecology* (Song Yongchang, 2001): leaf area 0–25 mm^2 was defined as leptophyll, 25–225 mm^2 as microphyll, 2.25–20.25 cm^2 as small leaf, 20.25–182.25 cm^2 as mesophyll, 182.25–1 642.25 cm^2 as macrophyll, and greater than 1 642.25 cm^2 as megaphyll. Indicator species of plant formations were classified according to Jin Zhenzhou (1998) for the Jinsha River valley region: first-level indicator species refer to species endemic to the dry-warm valley; second-level indicator species refer to species endemic to the Dianchuan region and ecological indicator species of dry-warm valleys; third-level indicator species are mainly ecological indicator species of valleys.

The importance value of species in the shrub layer/herb layer = (relative cover + relative frequency + relative density) / 3 (Song Yongchang, 2001). Species diversity was measured using the Shannon–Wiener index (H), Pielou evenness index (J), Simpson index (D), and species richness (R) (Ma Keping and Liu Yuming, 1994; Song Yongchang, 2001). The calculation formulas are as follows:

$$\text{Shannon–Wiener index } (H): \quad H = -\sum_{i=1}^{S} P_i \log_2 P_i;$$

$$\text{Pielou evenness index } (J): \quad J = H/\ln S;$$

$$\text{Simpson diversity index } (D): \quad D = 1 - \sum_{i=1}^{S} P_i^2;$$

$$\text{Richness index } (R): \quad R = S.$$

In the formulas: P_i is the importance value of species i; N is the total number of individuals of all species; and S is the number of species in the quadrat.

2 Results and analysis

2.1 Species composition and floristic characteristics of the community

2.1.1 Species composition A total of 194 species of vascular plants belonging to 120 genera and 57 families were recorded in the *Dulichium arundinaceum* community in Lijiang, including 12 species in 5 genera and 2 families of lycophytes and pteridophytes, 182 species in 115 genera and 55 families of seed plants, and no gymnosperms. The families with relatively many plant species were, in order, Fabaceae (19 species in 12 genera), Poaceae (14 species in 11 genera), Verbenaceae (8 species in 3 genera), and Asclepiadaceae (7 species in 5 genera). The genera with relatively many included *Carex* (5 species) and *Selaginella* (5 species). This is consistent with the results of previous surveys carried out in the Jinsha River basin (Ou Xiaokun, 1988; Jin Zhenzhou et al., 1994; Yang Qinzhou, 2007). There were 74 shrub species, accounting for 38.14% of the total number of species in the community; 96 herbaceous species, accounting for 49.48%; and 24 interlayer species, accounting for 12.37%.

Dominant species were conspicuous in each layer of the community. There were 33 shrub species with importance values greater than 1, accounting for 44.59% of the total number of shrub species. Among them, *Dulichium arundinaceum* had an importance value of 13.96, followed by *Terminalia franchetii*, with an importance value of 7.51. There were 24 herbaceous species with importance values greater than 1, accounting for 25.00% of the total number of herbaceous species; *Heteropogon contortus* and *Carex oxyphylla* had absolute dominance. There were 7 interlayer species with importance values greater than 1, accounting for 29.17% of the total number of interlayer species; *Dioscorea martinii* and *D. subcalva* were dominant.

2.1.2 Floristic characteristics The 120 genera of vascular plants in the community (including 28 cosmopolitan genera) can be divided into 12 areal types and 11 variants (Table 2). Among them, tropical genera (types 2–7) totaled 52 genera, accounting for 56.52% of the total number of genera, with pantropical genera and their variants being the most numerous, totaling 31 genera, such as *Dulichium* and *Sageretia*. Temperate genera (types 8–15) totaled 40 genera, accounting for 43.48% of the total number of genera, with north-temperate genera and their variants being the most numerous, totaling 13 genera, such as *Spiraea* and *Cotinus*. Mediterranean components totaled 4 genera, namely *Sedum* and [[unclear: text cut off after the character "+"]].

Mahonia, *Pistacia*, and *Pyracantha*; there were 3 Chinese endemic genera, namely *Ostryopsis*, *Trailliaedoxa*, and *Pterygiella*.

The 194 vascular plant species in the community can be divided into 9 distribution-area types and 16 variants. Among them, 2 species were cosmopolitan, namely feather fingergrass (*Chloris virgata*) and annual bluegrass (*Poa annua*); 20 species were tropical elements, accounting for 10.42% of the total number of species, among which the tropical Asian type and its variants had the largest number of species, totaling 14, such as *Cynanchum alatum* and *Bauhinia brachycarpa*. Temperate elements comprised 172 species, accounting for 89.58% of the total number of species, and Chinese endemic species numbered 118, accounting for 61.46%. Among these, 75 species belonged to the typical Chinese endemic type, such as *Desmodium yunnanense* and *Himalrandia lichiangensis*; 22 species belonged to the Yunnan endemic variant, such as *Leptodermis dielsianha* and *Euonymus compressus*; and 21 species belonged to the Jinsha River valley endemic variant, namely *Thalictrum viscosum*, *Ceropegia aridicola*, *Cymobopogon jinshaensis*, Lijiang bauhinia, *Sageretia lijiangensis*, *Cotinus nana*, *Elsholtzia capituligera*, *Acacia yunnanensis*, *Rhynchosia yunnanensis*, *Clematis delavayi*, Dian lanren, *Buxus mollicula* var. *glabra*, *Clausena vestita*, *Aralia yunnanensis*, *Cynanchum anthonyanum*, *Trailliaedoxa gracilis*, *Caryopteris forrestii*, *Chelonopsis siccanea*, *Dodonaea viscosa* subsp. *angustifolia*, *Pterygiella suffruticosa*, and *Aleuritopteris likiangensis*.

Table 2 Distribution area type statistics of vascular plant genera and species in the community of *Bauhinia bohniana*

No.	Type and subtype	Number of genera	Proportion of genera (%)	Number of species	Proportion of species (%)
1	Cosmopolitan	28	–	2	–
2	Pantropical distribution	25	27.17	–	–
2-1	Tropical Asia, Australasia (to N. Zealand) & Central to South America	3	3.26	1	0.52
2-2	Tropical Asia, Africa & Central to South America, disjunct	3	3.26	–	–
4	Old World Tropics	1	1.09	1	0.52
4-1	Tropical Asia, Africa (or East Africa, Madagascar) & Australasia, disjunct	8	8.70	1	0.52

No.	Type and subtype	Number of genera	Proportion of genera (%)	Number of species	Proportion of species (%)
5	Tropical Asia & tropical Australasia	2	2.17	–	–
6	Tropical Asia to tropical Africa	6	6.52	–	–
6-1	South and Southwest China to India & tropical Africa, disjunct	–	–	2	1.04
6-2	Tropical Asia & East Africa or Madagascar, disjunct	–	–	1	0.52
7	Tropical Asia (i.e., tropical Southeast Asia to Indo-Malesia and the Pacific islands)	4	4.35	3	1.56

No.	Type and subtype	Number of genera	Proportion of genera (%)	Number of species	Proportion of species (%)
7-1	Java (or Sumatra) and the Himalaya to South and Southwest China, disjunct or diffuse	—	—	3	1.56
7-2	Tropical India to South China, especially southern Yunnan	—	—	4	2.08
7-3	Burma and Thailand to Southwest China	—	—	1	0.52

Code	Distribution type	Count	%	Count	%
7-4	Vietnam (or the Indochinese Peninsula) to South China (or Southwest China)	–	–	3	1.56
8	North Temperate	12	13.04	4	2.08
8-4	Disjunct between the North Temperate and South Temperate zones	1	1.09	1	0.52
9	Disjunct between East Asia and North America	2	2.17	–	–
9-1	Disjunct between East Asia and Mexico	1	1.09	–	–
10	Old World Temperate	1	1.09	6	3.13

Code	Distribution type	Count	%	Count	%
10-1	Disjunct among the Mediterranean region, West Asia (or Central Asia), and East Asia	1	1.09	–	–
10-2	Disjunct between the Mediterranean region and the Himalaya	–	–	1	0.52
10-3	Disjunct between Eurasia and South Africa (sometimes also Australasia)	3	3.26	2	1.04
11	Temperate Asia	3	3.26	–	–

Code	Distribution type	Count	%	Count	%
12-3	Disjunct from the Mediterranean region to temperate–tropical Asia, Australasia, and southern North America to South America	3	3.26	–	–
12-5	Disjunct from the Mediterranean region to North Africa, Central Asia, southwestern North America, southern Africa, Chile, and Australasia	–	–	1	0.52
13	Central Asia	–	–	2	1.04

Code	Distribution type	Count	%	Count	%
13-1	Eastern Central Asia (Middle Asia), in Xinjiang (especially Kashgaria), Gansu, Qinghai to Mongolia	–	–	2	1.04
13-2	Central Asia to the Himalaya and Southwest China	–	–	4	2.08
13-3	West Asia to the western Himalaya and Tibet	1	1.09	–	–
14	East Asia	5	5.43	17	8.85
14SH	China–Himalaya; Sino-Himalaya (SH)	3	3.26	11	5.73
14SJ	China–Japan; Sino-Japan (SJ)	1	1.09	3	1.56

Code	Distribution type	Count	%	Count	%
15	Endemic to China	3	3.26	75	39.06
15-1	Endemic to Yunnan	–	–	22	11.46
15-2	Endemic to the Jinsha River Valley	–	–	21	10.94

2.2 Community Structure and Adaptive Characteristics

Field investigations and interpretation of UAV imagery show that the *Bauhinia* community in Lijiang is mainly distributed within an approximately 2 km stretch of river valley around Baima Chang Village on the east-facing slope of the left bank of the Jinsha River in Shangri-La City. Scattered occurrences are also found on the right bank of the Jinsha River. The community occurs at elevations from 1,580 m to 2,300 m, covering an area of about 300 hm^2.

2.2.1 Vertical Structure and Community Physiognomy

The community shows clear vertical stratification, including a shrub layer, an herb layer, and an interlayer. The shrub layer is the principal structural layer and is composed of Lijiang bauhinia, Dianlanren, Mingyouzi, fragrant pistache (*Pistacia weinmanniifolia*), and others; its coverage is 30%-70% and its height is 2-4 m. The herb layer is 0.1-0.8 m high and mainly includes Scutellaria, lemongrass (*Cymbopogon distans*), and Vietnamese balm (*Elsholtzia ciliata*), with coverage of 10%-50%. The interlayer is dominated mostly by white-hairy yam, hairy-gum yam, creeping pigeonpea (*Cajanus scarabaeoides*), and Yunnan stemona (*Stemona mairei*), with coverage of 1%-3% and a height of up to 2 m.

The community physiognomy has the typical characteristics of xerophytic deciduous scrub, and seasonal changes are extremely pronounced. During the long dry season, the community appears withered, yellow, sparse, and defoliated; with the arrival of the rainy season, however, it rapidly regains vitality (Fig. 2). In late March to early April, shrubs in the community begin to partially re-[[unclear: word continues on next page after “复”]]

…recovered; in June, most areas of Yunnan have already entered the rainy season, whereas the mean precipitation in June in the study area over the past 10 years was only 53.46 mm, and the area had not yet entered the rainy season. As a result, the herbaceous layer of the community remained withered and collapsed in June, and its phenology was extremely delayed. Precipitation increased gradually in July, and the herbaceous layer then began to recover. After November, precipitation decreased sharply; correspondingly, the shrub layer gradually entered the leaf-fall period, the herbaceous layer gradually withered and collapsed, and the community appearance became withered. This strong seasonal contrast is the most direct response of the community to the pronounced seasonal changes in hydrothermal conditions.

A. Habitat of the *Bauhinia bohniana* community (April 22, 2023); **B.** Appearance of the *Bauhinia bohniana* community (June 10, 2023); **C.** Flowers and fruits of *B. bohniana* (June 10, 2023); **D.** *B. bohniana* community (June 10, 2023; herbaceous layer not yet recovered); **E.** Appearance of the *Bauhinia bohniana* community (June 12, 2023); **F.** Habitat of the *Bauhinia bohniana* community (July 16, 2024).

A. *Bauhinia bohniana* community habitat (April 22, 2023); **B.** Appearance of *B. bohniana* community (June 10, 2023); **C.** Flowers and fruits of *B. bohniana* (June 10, 2023); **D.** *B. bohniana* community (June 10, 2023; herbaceous layer not yet recovered); **E.** Appearance of *B. bohniana* community (June 12, 2023); **F.** Habitat of *B. bohniana* community (July 16, 2024).

Fig. 2 Habitat and appearance of *Bauhinia bohniana* community in the Jinsha River valley

2.2.2 Life-form structure of the community

In the community, chamaephytes were the most numerous, with 80 species in total (Table 3), accounting for 41.24% of the total number of species. They were followed by phanerophytes, with 67 species, accounting for 34.54% of the total; hemicryptophytes and geophytes comprised 36 species, accounting for 18.56% of the total; annual herbs were the fewest, with 11 species, accounting for only 5.67% of the total. In terms of leaf texture, the flora was dominated by papery leaves (64.06%) (Fig. 3); in leaf type, by simple leaves (77.08%); in leaf margin, by entire leaves (66.67%); and in leaf size class, by microphylls (50.52%).

Table 3. Life-form spectrum of the *Bauhinia bohniana* community

Life form	Species count/Percentage (%)	Seedling toppling count/Percentage (%)	Leaf-shedding and renewal count/Percentage (%)	Evergreen count/Percentage (%)	Evergreen succulent count/Percentage (%)
Nano-phanerophytes	42/21.65%	–	41/21.13	1/0.52	–
Micro-phanerophytes	25/12.89%	–	17/8.76	8/4.12	–
Chamaephytes	16/8.25%	2/1.03	11/5.67	3/1.55	–

Life form	Species count/Percentage (%)	Seedling toppling count/Percentage (%)	Leaf-shedding and renewal count/Percentage (%)	Evergreen count/Percentage (%)	Evergreen succulent count/Percentage (%)
Hemicryptophytes	80/41.24%	73/37.63	4/2.06	–	3/1.55
Geophytes	20/10.31%	20/10.31	–	–	–
Therophytes	11/5.67%	9/4.64	2/1.03	–	–
Total	194/100%	104/53.61	75/38.65	12/6.19	3/1.55

Leaf phase

Y-axis: Percentage (%).

Visible bar-chart categories and values:

- **Leaf texture (LT):** Ch. chartaceous, 64.06%; Or. orthophyll, 12.5%; Sc. sclerophyll, 15.1%; Me. membranaceous, 6.77%; Su. succulent, 1.56%.
- **Leaf shape (LS):** SL. simple leaf, 77.08%; CL. compound leaf, 22.92%.
- **Leaf margin (LM):** NE. non-entire, 33.33%; En. entire, 66.67%.
- **Leaf size class (LR):** Na. nanophyll, 27.6%; Br. scale leaf, 3.13%; Mi. microphyll, 50.52%; Me. mesophyll, 18.75%.

Abbreviations: LT. Leaf texture; Ch. Chartaceous; Or. Orthophyll; Sc. Sclerophyll; Me. Membranaceous; Su. Succulent. LS. Leaf shape; SL. Simple leaf; CL. Compound leaf. LM. Leaf margin; NE. Non-entire; En. Entire. LR. Leaf size class; Na. Nanophyll; Br. Scale leaf; Mi. Microphyll; Me. Mesophyll.

Simple leaf; **CL.** Compound leaf. **LM.** Leaf margin **NE.** Non-entire; **E.** Entire. **LR.** Leaf rank **Na.** Nanophyll; **Br.** Bryophyll; **Mi.** Microphyll; **Me.** Mesophyll.

Fig. 3 Leaf phase characteristics of the *Bauhinia bohniana* community

Fig. 3 Leaf phase characteristics of *Bauhinia bohniana* community

2.2.3 Morphological and climatic adaptation to a hot environment

To adapt to the environmental stresses of the "asynchrony between rainfall and heat" and the short effective growing season in dry-warm valleys, the community plants have evolved a series of coordinated morphological and climatic adaptation strategies. Among woody plants, 18 species are recorded as evergreen in floras, but in the study area they behave as deciduous species, such as firethorn (*Pyracantha fortuneana*), etc. In addition, the leaves of most plants are markedly smaller than those recorded in floras. For example, the leaves of *Abelia forrestii* are recorded in the *Flora of Yunnan* as 1–2 cm long and 3–7 mm wide, whereas in the study area the leaves of *Abelia forrestii* are 4–7 mm long and about 3 mm wide, clearly smaller than the flora records. The reason is that the rainy season in this area arrives late, precipitation is low, and the dry season is long; the effective growing time of species is short, the phenological phase is delayed, and leaves become smaller. Leaf miniaturization is a classic xeromorphic adaptive trait that reduces transpiring area and improves water-use efficiency.

2.3 Dry-warm valley indicator species of the community

According to the Jinsha River dry-warm valley indicator-species system established by Professor Jin Zhenzhou (Jin Zhenzhou, 1998), a total of 51 indicator species were recorded in this community, providing evidence that the community is typical vegetation of a dry-warm valley. Among them, there are 8 first-level indicator species, accounting for 15.69% of the total number of indicator species in this community and 44.44% of the first-level indicator species in the Yunnan–Sichuan dry-warm valley of the Jinsha River, including Aihuanglu, Yunnan Baibu, Dingqian, Maoye Huangpi, *Bauhinia bohniana*, Zhan Tang Songcao, *Aristolochia delavayi*, and Chuandian Chijingmu. There are 35 second-level indicator species, accounting for 68.63% of the total number of indicator species in this community and 33.98% of the first-level indicator species in the Yunnan–Sichuan dry-warm valley of the Jinsha River, such as Dianlanren, *Wikstroemia lichiangensis*, Qingxiangmu, etc. There are 8 third-level indicator species, accounting for 15.69% of the total number of indicator species in this community and 21.62% of the first-level indicator species in the Yunnan–Sichuan dry-warm valley of the Jinsha River, such as *Cotinus coggygria* var. *glaucophylla*, *Eriophorum comosum*, and Yixiangcao. Second-level indicator species are relatively numerous, whereas first-level indicator species are the core species with the strongest adaptability to dry-warm valley habitats and the narrowest distribution ranges within the region. The occurrence of many indicator species shows that this community is a typical representative of dry-warm valleys and further highlights the irreplaceable value of the study area in conserving the region' s unique biodiversity.

2.4 Relationship between community species diversity and habitats

In this study, the species diversity of the *Bauhinia bohniana* community showed significant hierarchical differences in vertical structure, with the shrub layer being the layer with the highest diversity level in the community (Table 4). Data analysis showed that the mean values of the Shannon–Wiener index (H), Pielou evenness index (J), and species richness (R) of the shrub layer ($1.89 \pm 0.52,\ 0.79 \pm 0.20,\ 11.82 \pm 3.65$) were all significantly higher than those of the herb layer ($1.01 \pm 0.35,\ 0.45 \pm 0.15,\ 10.05 \pm 3.43$). These data indicate that, as the dominant layer of the community, the shrub-layer community structure is more complex.

Table 4 Diversity indices of the *Bauhinia bohniana* community

Table 4 Diversity indices of *Bauhinia bohniana* community

Layer	Index	Mean	Std. Dev.	Min.	Max.
Shrub layer	H	1.89	0.52	0.25	3.12
Shrub layer	J	0.79	0.20	0.11	1.21
Shrub layer	R	11.82	3.65	5.00	19.00
Herb layer	H	1.01	0.35	0.02	1.47
Herb layer	J	0.45	0.15	0.01	0.64
Herb layer	R	10.05	3.43	4.00	17.00

Within the community, mature individuals of *Bauhinia bohniana* are distributed in patches. In areas with relatively low rock exposure and gentle terrain, shrub-layer coverage is higher and species are more numerous. The distribution of shrub-layer species is strongly affected by local habitats; for example, Qingxiangmu and Maoye Huangpi are mostly distributed in areas with thicker soil and gentler slopes, whereas more drought-tolerant species such as Dingqian and Chuandian Chijingmu are distributed in areas with higher rock exposure. Herb-layer plants are relatively scattered in distribution, showing

It is distributed in patches or bands, and its cover is strongly affected by precipitation and soil-water conditions. Herbaceous plants are relatively abundant in gullies or places where rainwater converges, whereas on steeper slopes and in areas where soil moisture is deficient, the cover of the herb layer is low, and bare-ground patches may even occur.

3 Discussion

3.1 Uniqueness of species composition under environmental filtering in dry-warm valleys

The *Bauhinia lijiangensis* community contains 118 species endemic to China, accounting for 61.46% of the total number of species. This result is consistent with Li Yunqin' s (2019) study of the arid valleys in the upper reaches of the Jinsha River, where the proportion of Chinese endemic species was 54.05%, and with Cha Wuting' s (2023) study of *Firmiana major* communities in the Jinsha River basin, where the proportion of Chinese endemic species was 57.97%; however, the proportion of Chinese endemic species in this community is even more pronounced. The concentrated distribution of endemic species is a salient feature of the flora of this community. In this steep, narrow, and enclosed valley, the dry-hot climatic effect produced by "foehn winds" has promoted the evolution of numerous Chinese endemic species. Endemic elements reflect the characteristics and uniqueness of the recent and modern floristic evolution of this region (Zhu Hua, 2008). This indicates that the species flora of the *Bauhinia lijiangensis* community has been deeply influenced by the retreat of the ancient Mediterranean and the uplift of the Himalayas (Zhu Hua et al., 2024); the uplift of the Qinghai–Tibet Plateau caused the tropical *Bauhinia lijiangensis* to retreat into local valley habitats. Similar to the dry-hot valleys of the Yuanjiang and

Honghe rivers, the *Bauhinia lijiangensis* community is dominated by Fabaceae and Poaceae, with shrub layers prevailing, as seen in species such as *Huangmao* and lemongrass; this reflects the convergent adaptation of dry-hot valley vegetation to drought (Ou Xiaokun, 1988). The characteristics of small and papery leaves are similar to those of African savanna communities, such as acacia scrub, and both represent survival strategies for reducing transpiration (Jin Zhenzhou, 1988).

There are 51 indicator species of dry-warm valleys in the *Bauhinia lijiangensis* community, including 8 first-level indicator species, accounting for 15.69% of the dry-warm-valley indicator species in this community. *Bauhinia lijiangensis*, as a first-level indicator species and also the dominant species of the community, provides shelter through its canopy for understory herbs and seedlings, and thus occupies an extremely important ecological position in the community. Among the first-level indicator species, some are derived from tropical genera, such as *Bauhinia lijiangensis*, perfoliate birthwort, hairy-leaved wampee, and Yunnan stemona, while others are elements of temperate genera, such as Dingqian, dwarf smoketree, and Sichuan–Yunnan wing-stem tree (Wu Zhengyi, 1991; Feng Jianmeng and Zhu Youyong, 2010). This suggests that the region had a tropical environment at an earlier historical stage, but in recent and modern times has tended toward a temperate environment because of the uplift of the Qinghai–Tibet Plateau. There are 35 second-level indicator species, accounting for 68.63%, and 8 third-level indicator species, accounting for 15.69%. The first-level dry-warm-valley indicator species in the community account for 44.44% of the first-level indicator species in the Yunnan–Sichuan dry-warm valleys of the Jinsha River. As typical species adapted to dry-warm valley environments, dry-warm-valley indicator species are of great significance for the classification of community types and the protection of dry-warm valley ecosystems (Song Yongchang et al., 2017), and also provide a basis for further study of the role of indicator species in ecosystem functions. As the absolute dominant species, the patchy distribution of *Bauhinia lijiangensis* is closely related to microhabitats such as rock exposure rate and soil thickness, demonstrating the adaptive strategies of dry-warm valley plants to heterogeneous habitats (Yang Qinzhou, 2007). The proportion of first-level indicator species in the *Bauhinia lijiangensis* community (44.44%) exceeds that in the dry-hot valleys of the Yuanjiang River (about 15%), possibly because geological activity in the Jinsha River basin is more active and the rock-fragmentation rate is high, thereby giving rise to more narrowly endemic species (Jin Zhenzhou, 1998). The uniqueness of the *Bauhinia lijiangensis* community arises from the synergistic effects of geographical isolation, historical disturbance, and extreme environments; its differences from other dry-hot valley vegetation reflect the dual role of the Hengduan Mountains as both an "ecological corridor" and a "barrier" (Yuan Yongqi et al., 2024).

3.2 Coordinated adaptation of community structure and the dry-warm valley environment

This study found that the species diversity of the shrub layer in the *Bauhinia lijiangensis* community was significantly higher than that of the herb layer, revealing that differences in vertical structure within the community are an important mechanism maintaining its species diversity. As the absolute dominant species, *Bauhinia lijiangensis* not only constitutes the main body of the community, but its canopy also effectively improves the understory microclimate by providing shade, intercepting moisture, and accumulating litter, thereby lowering surface temperature and increasing soil moisture and nutrients. This provides a suitable "shelter" for relatively drought-intolerant associated shrubs such as hairy-leaved wampee, that is, an ecological facilitation effect. It is precisely the habitat heterogeneity created by *Bauhinia lijiangensis* that makes shrub-layer diversity higher than herb-layer diversity.

Life-form characteristics can, to a certain extent, reflect the ecological habits of plants, while the life-form spectrum of a community can reflect its physiognomy and structural characteristics (Gao Xianming and Chen Lingzhi, 1998). The vertical stratification of the *Bauhinia lijiangensis* community—the shrub layer, herb layer, and interlayer plants—is closely related to habitats characterized by steep terrain and high rock exposure rates (60%-90%). The shrub layer occupies the dominant position, with cover of 30%-70%, and its diversity index is significantly higher than that of the herb layer, indicating that shrubs have greater advantages in competition for environmental resources and in niche differentiation. For example, species such as fragrant pistache prefer gentle slopes with relatively thick soils, whereas drought-tolerant species such as Dingqian are adapted to areas with high rock exposure, reflecting the driving role of "habitat filtering" in community composition (Chen Zhaoquan et al., 2024). The patchy distribution of the herb layer is highly correlated with the spatiotemporal heterogeneity of precipitation: herbaceous cover is higher in gullies, whereas in steep-slope areas it is poorly developed and even bare ground appears, reflecting the limiting effect of water on herbaceous communities.

In the life-form spectrum of the *Bauhinia lijiangensis* community, hemicryptophytes account for the highest proportion (41.67%), followed by phanerophytes (33.85%) and geophytes (10.42%), while chamaephytes (8.33%) and annuals (5.73%) are relatively few. Xin Zhiming et al. (2024), in their study of Wu···

Studies of the Ulan Buh Desert have shown that high proportions of hemicryptophytes and phanerophytes are manifestations of plant adaptation to extreme drought. Li Jiaxiang et al. (2017), in their study of the life forms of subtropical shrubland plants in China, found that phanerophytes and hemicryptophytes were the main dominant components, which is consistent with the results of the present study. In the community, woody shrubs are dominated by phanerophytes, resuming growth from late March to early April and entering the leaf-fall period after November; herbaceous plants begin to unfold leaves in July and gradually wither and lodge in December. Phenology is delayed and the growing season is markedly short, resulting in delayed species phenology within the community. Phanerophytes respond to drought by shedding and replacing leaves, whereas hemicryptophytes, mainly herbs, adapt to drought through lodging. Plant leaves are highly sensitive to the growth environment, and leaf morphology differs markedly under warm-humid and arid conditions (Jassal et al., 2008). Compared with other regions, the leaves in the *Bauhinia* community of Lijiang are more reduced in size and are mainly papery in texture. In the warm-dry valley environment where water resources are scarce, smaller leaves can reduce water loss by decreasing leaf surface area and transpiring surface area (Wu Yiling et al., 2024), which is conducive to plant survival under drought conditions. The phenological and leaf-type traits of the community further verify its adaptive mechanisms to arid environments. These traits are similar to the phenomenon of convergent evolution in shrublands of Mediterranean-climate regions (Valladares et al., 2007), but the *Bauhinia* community of Lijiang has a relatively high proportion of temperate elements (43.48%), and species endemic to China account for 61.46% (including 21 species endemic to the Jinsha River), highlighting the distinctiveness of its topographic environment and climate.

4 Conclusion

Bauhinia of Lijiang is a narrowly distributed endemic plant of the transition zone from Shangri-La to Lijiang to Ninglang in the middle reaches of the Jinsha River, and it forms a distinctive *Bauhinia* community in the study area. This study revealed the species composition, floristic characteristics, structural features, and environmental adaptation mechanisms of the community, showing typical xerophytic shrubland traits. With the retreat of the ancient Mediterranean Sea and the uplift of the Himalayas, the enclosed environment created by the deeply incised V-shaped valley of the Jinsha River provided suitable survival conditions for *Bauhinia* of Lijiang, allowing it to persist in this region. However, the current community area is only about 300 hm^2, and the community is still subject to strong disturbance from human activities. According to the IUCN threatened species assessment criteria (IUCN, 2022; Meng Jiahui et al., 2024), *Bauhinia* of Lijiang has a narrow distribution range, a small community area, and an extremely harsh habitat, and should be classified as an Endangered species (EN). It is recommended that *Bauhinia* of Lijiang be included in the national list of key protected wild plants and that effective management and conservation measures be adopted to ensure its persistence in the dry-warm valley ecosystem of the Jinsha River.

Acknowledgments: The field investigation of this study lasted more than one year, during which we received strong support from the Administration Bureau of the Haba Snow Mountain Nature Reserve. We hereby express our sincere gratitude. In addition, more than ten teachers and students participated in this scientific expedition to the Haba Snow Mountain Nature Reserve, providing valuable support and assistance for the successful completion of the research.

We also express our heartfelt thanks to them.

References:

CHA WJ, SHI M, DU F, et al., 2023. Community characteristics of tiny population *Firmiana major* [J]. Journal of Southwest Forestry University (Natural Sciences), 43(3): 71-78. [Cha Wujing, Shi Ming, Du Fan, et al., 2023. Study on community characteristics of the extremely small population species *Firmiana major* [J]. Journal of Southwest Forestry University (Natural Sciences), 43(3): 71-78.]

CHEN K, 1938. New species of *Bauhinia* from CHINA [J]. Journal of the Arnold Arboretum, 19(2): 129-133.

CHEN ZQ, WANG MH, HU ZH, et al., 2024. Mechanisms of seedling community assembly in a monsoon evergreen broadleaf forest in Puer, Yunnan, China [J]. Chinese Journal of Plant Ecology, 48(1): 68-79. [Chen Zhaoqian, Wang Minghui, Hu Zihan, et al., 2024. Mechanisms of seedling community assembly in a monsoon evergreen broadleaf forest in Pu' er, Yunnan [J]. Chinese Journal of Plant Ecology, 48(1): 68-79.]

FENG JM, ZHU YY, 2010. On the genera of seed plants endemic to China in Yunnan [J]. Ecology and Environmental Sciences, 19(3): 621-625. [Feng Jianmeng, Zhu Youyong, 2010. Study on the genera of seed plants endemic to China in Yunnan [J]. Ecology and Environmental Sciences, 19(): 621-625.]

GAO XM, CHEN LZ, 1998. The revision of plant Life-Form system and an analysis of the Life-Form spectrum of forest plants in the warm temperate zone of China [J]. Journal of Integrative Plant Biology, 40(6): 70-76. [Gao Xianming, Chen Lingzhi, 1998. Revision of the plant life-form classification system and analysis of the life-form spectrum of forest plants in the warm temperate zone of China [J]. Acta Botanica Sinica, 40(6): 70-76.]

IUCN, 2022. The IUCN Red List of Threatened Species, Version 2021-3 [DB/OL]. (2022-07-22)[2025-07-12].

https://www.iucnredlist.org.

JASSAL R, BLACK, ANDY, et al., 2008. Effect of soil water stress on soil respiration and its temperature sensitivity in an 18-year-old temperate Douglas-fir stand [J]. *Global Change Biology*, 14: 1305-1318.

JIN ZZ, 1998. Study on the floristic elements of seed plants in the dry-warm valleys of Yunnan and Sichuan [J]. *Guihaia*, 18(4): 313-321. [Jin Zhenzhou, 1998. Study on the floristic elements of seed plants in the dry-warm valleys of Yunnan and Sichuan [J]. *Guangxi Zhiwu*, 18(4): 313-321.]

JIN ZZ, 2002. Floristic features of dry-hot and dry-warm valleys, Yunnan and Sichuan [M]. Kunming: Yunnan Science and Technology Press: 1-5. [Jin Zhenzhou, 2002. Floristic features of dry-hot and dry-warm valleys, Yunnan and Sichuan [M]. Kunming: Yunnan Science and Technology Press: 1-5.]

JIN ZZ, OU XK, QU PD, et al., 1994. A preliminary study on the floristic characteristics of seed plants in the dry-hot river valley of Jinsha River [J]. *Acta Botanica Yunnanica*, 16(1): 1-16. [Jin Zhenzhou, Ou Xiaokun, Qu Puding, et al., 1994. A preliminary study on the floristic characteristics of seed plants in the dry-hot valley of the Jinsha River [J]. *Yunnan Zhiwu Yanjiu*, 16(1): 1-16.]

LI CJ, CHEN YL, YANG FM, et al., 2020. Population structure and regeneration dynamics of *Firmiana major*, a dominant but endangered tree species [J]. *Forest Ecology and Management*, 462: 117993.

LI JX, XIONG GM, XU WT, et al., 2017. Composition of plant life forms of subtropical shrubland in China and its correlation with temperature and precipitation [J]. *Chinese Journal of Plant Ecology*, 41(1): 147-156. [Li Jiaxiang, Xiong Gaoming, Xu Wenting, et al., 2017. Composition of plant life forms of subtropical shrublands in China and its correlation with hydrothermal factors [J]. *Chinese Journal of Plant Ecology*, 41(1): 147-156.]

LI YQ, DU F, WANG J, 2019. Floristic characteristics of vascular plants in dry valleys of the upstream of Jinsha River [J]. *Journal of West China Forestry Science*, 48(1): 93-99, 138. [Li Yunqin, Du Fan, Wang Jian, 2019. Floristic characteristics of vascular plants in the dry valley area of the upper Jinsha River [J]. *Journal of West China Forestry Science*, 48(1): 93-99, 138.]

LIU YP, XU XT, DIMITROV D, et al., 2023. An updated floristic map of the world [J]. *Nature Communications*, 14(1): 2990.

LU SG, 2004. Pteridology [M]. Beijing: Higher Education Press: 299-362. [Lu Shugang, 2004. Pteridology [M]. Beijing: Higher Education Press: 299-362.]

MA KP, LIU YM, 1994. Methods for measuring biological community diversity: I. Measurement of α-diversity (Part II) [J]. *Biodiversity Science*, 2(4): 231-239. [Ma Keping, Liu Yuming, 1994. Methods for measuring biological community diversity: I. Methods for measuring α-diversity (Part II) [J]. *Biodiversity Science*, 2(4): 231-239.]

MENG JH, CUI Y, LUO A, et al., 2024. Threat assessment of future climate change to China's seed plants [J]. *Scientia Sinica (Vitae)*, 54(4): 751-765. [Meng Jiahui, Cui Yu, Luo Ao, et al., 2024. Assessment of threat levels to China' s seed plants under future climate-change scenarios [J]. *Scientia Sinica: Vitae*, 54(4): 751-765.]

OU XK, 1988. The study of flora in Yuanmou dry-hot River valley [J]. *Acta Botanica Yunnanica*, 10(1): 11-18. [Ou Xiaokun, 1988. Study on the flora of the dry-hot valley of Yuanmou [J]. *Yunnan Zhiwu Yanjiu*, 10(1): 11-18.]

Qinghai-Tibet Plateau Scientific Expedition of the Chinese Academy of Sciences, 1986. Special issue on Hengduan Mountains (II) [C]. Beijing: Beijing Science and Technology Press: 416-431. [Qinghai-Tibet Plateau Comprehensive Scientific Expedition Team, Chinese Academy of Sciences, 1986. Special Issue of the

Scientific Expedition to the Hengduan Mountains of the Qinghai-Tibet Plateau (II) [C]. Beijing: Beijing Science and Technology Press: 416-431.]

RUAN CM, WANG M, SUN YY, et al., 2024. Characteristics of soil fertility and the influencing factors in the hot-dry valley of Jinsha River [J]. *Chinese Journal of Soil Science*, 55(1): 93-101. [Ruan Changming, Wang Meng, Sun Yongyu,

et al., 2024. Characteristics of soil fertility in the dry-hot valleys of the Jinsha River Basin and their influencing factors [J]. Chinese Journal of Soil Science, 55(1): 93-101.]

SHEN ZH, ZHANG ZM, HU JM, et al., 2016. Protection and utilization of plant biodiversity resources in dry valleys of Southwest China [J]. Biodiversity Science, 24(4): 475-488. [SHEN Zehao, ZHANG Zhiming, HU Jinming, et al., 2016. Protection and utilization of plant biodiversity resources in the dry valleys of Southwest China [J]. Biodiversity Science, 24(4): 475-488.]

SONG YC, 2001. Vegetation Ecology [M]. Shanghai: East China Normal University Press: 43-102. [SONG Yongchang, 2001. Vegetation Ecology [M]. Shanghai: East China Normal University Press: 43-102.]

SONG YC, YAN ER, SONG K, 2017. An update of the vegetation classification in China [J]. Chinese Journal of Plant Ecology, 41(2): 269-278. [SONG Yongchang, YAN Enrong, SONG Kun, 2017. Revisiting the vegetation classification system of China [J]. Chinese Journal of Plant Ecology, 41(2): 269-278.]

TAO J, 2011. Biodiversity and its conservation in Habaxueshan Nature Reserve, Yunnan, China [D]. Beijing: Chinese Academy of Forestry: 8-11. [TAO Jing, 2011. Study on biodiversity and conservation in the Haba Snow Mountain Nature Reserve, Yunnan [D]. Beijing: Chinese Academy of Forestry: 8-11.]

VALLADARES F, GIANOLI E, GÓMEZ JM, 2007. Ecological limits to plant phenotypic plasticity [J]. New Phytologist, 176(4): 749-763.

WU YL, LI FL, BAO WK, et al., 2024. Latitudinal pattern and causes of leaf vein traits of *Bauhinia brachycarpa* in arid valley [J]. Chinese Journal of Ecology, 43(11): 1-11. [WU Yiling, LI Fanglan, BAO Weikai, et al., 2024. Latitudinal pattern and causes of leaf vein traits of *Bauhinia brachycarpa* in arid valleys [J]. Chinese Journal of Ecology, 43(11): 1-11.]

WU ZY, 1991. The areal-types of Chinese genera of seed plants [J]. Acta Botanica Yunnanica, 13(Suppl. IV): 1-139. [WU Zhengyi, 1991. The areal-types of Chinese genera of seed plants [J]. Acta Botanica Yunnanica, 13(Suppl. IV): 1-139.]

XIN ZM, SHAO QW, WANG X, et al., 2024. Plant diversity and aboveground biomass of oasis-desert vegetation in Ulan Buhe Desert [J]. Acta Ecologica Sinica, 44(18): 1-13. [XIN Zhiming, SHAO Qixia, WANG Xiang, et al., 2024.

Plant diversity and aboveground biomass of vegetation in the oasis–desert ecotone of the Ulan Buh Desert [J]. Acta Ecologica Sinica, 44(18): 1–13.]

YANG QZ, 2007. Study on the arid-valley scrubs in the upper reaches of Minjing River [J]. Mountain Research, 25(1): 1–32. [YANG Qinzhou, 2007. Study on the arid-valley shrubs in the upper reaches of the Minjiang River [J]. Mountain Research, 25(1): 1–32.]

YUAN YQ, FENG JR, LI DH, 2024. Community succession from different perspectives of life concepts [J]. Biology Bulletin, 59(1): 89–94. [YUAN Yongqi, FENG Jingru, LI Dehong, 2024. "Community succession" from the perspective of different concepts of life [J]. Biology Bulletin, 59(1): 89–94.]

ZHAO DL, ZHU SR, 2024. Spatiotemporal changes and influencing factors of vegetation coverage in the Jinsha River dry-hot valley from 2010 to 2021 [J]. Chinese Journal of Ecology, 43(8): 1–11. [ZHAO Donglin, ZHU Shirong, 2024. Spatiotemporal changes and influencing factors of vegetation coverage in the Jinsha River dry-hot valley from 2010 to 2021 [J]. Chinese Journal of Ecology, 43(8): 1–11.]

ZHU H, 2008. Distribution patterns of genera of Yunnan seed plants with references to their biogeographical significances [J]. Advances in Earth Science, 23(8): 830–839. [ZHU Hua, 2008. Distribution patterns of genera of Yunnan seed plants and their significance in floristic geography [J]. Advances in Earth Science, 23(8): 830–839.]

ZHU H, TAN YH, YANG YP, 2024. Review on savanna vegetation in the dry hot river valleys of southwestern China [J]. Plant Science Journal, 42(5): 682–696. [ZHU Hua, TAN Yunhong, YANG Yongping, 2024. A review of savanna vegetation in the dry-hot river valleys of southwestern China [J]. Plant Science Journal, 42(5): 682–696.]

Note: Figure translations are in progress. See original paper for figures.